Modeling the source of emissions from animal feeding operations

W. Powers, Iowa State University
R. Angel and R. Kohn, Univ. of Maryland
D. Meyer, Univ. of California, Davis

Objectives

- Identify the current deficiencies in the animal and manure handling component of the conceptual farm-level mass balance model proposed by the Committee on Animal Nutrition (NRC, 2003) that estimates emission concentrations and identifies the relative proportion of each form of emission (ie., N_2, NO_x, NH_3) based on nutrient flows through a whole farm system,

Objectives

- Establish emission data for ammonia, hydrogen sulfide, nitrogen oxides, sulfur oxides, methane, and specific volatile organic carbons from the animals themselves when fed typical diets,

Objectives

- Identify promising feed strategies and measure emission reductions in ammonia, hydrogen sulfide, nitrogen oxides, sulfur oxides, methane, and specific volatile organic carbons that occur following implementation of the dietary changes,

Objectives

- Challenge the existing model with actual mass balance data obtained from the research proposed in this grant and modify the model, as needed, based on the actual animal generated mass balance information such that the accuracy of the model to predict air emissions is improved,

Objectives

- Determine the proportion of the total emissions that is accounted for by the different components of the model as well as the measurements that go into the model components so that a few measurements can be identified that account for the greatest proportion of the air emissions. These measurements would be shared with regulatory agencies as the best implementation tools at the farm level,

Objectives

- Impart the information learned and strategies identified to students, producers, and policymakers, and

Objectives

- Use the information gained to move forward on the long-term goals of the research team that focus on implementation of the modified model to whole farm systems and evaluates the impact of emissions on animal health with potential impacts on worker and citizen health, using the animal as a model receptor.

Effects of reduced crude protein diets on gaseous emissions and swine performance

W.J. Powers, S.B. Bastyr, B.J. Kerr

Objectives

- To quantify the effects of reduced crude protein diets on air emissions, and
- To evaluate animal performance when fed reduced crude protein diets throughout the grow-finish phase

Materials and Methods

- Pigs were housed in the Air Emissions Laboratory
  - Constructed to provide separate air spaces for emissions work

Materials and Methods

- 48 barrows, assigned to one of 8 rooms
  - Heavy group = 30.1 lb
  - Light group = 23.4 lb
- 5 ft x 10 ft pen
- 14-d acclimation

Analyzed composition of dietary treatments during the four feeding phases.

Item	*Grower phase 1*			*Grower phase 2*			*Finisher phase 1*			*Finisher phase 2*		
	C[b]	LCP	ULCP	C	LCP	ULCP	C	LCP	ULCP	C	LCP	ULCP
Crude protein, %	22.1	18.8	17.2	19.9	18.3	16.7	17.7	15.6	14.1	16.1	14.5	12.0
Lysine, %	1.35	1.30	1.30	1.25	1.22	1.23	1.12	1.09	1.09	1.04	0.94	0.96
Methionine, %	0.37	0.39	0.42	0.35	0.36	0.36	0.32	0.30	0.29	0.29	0.26	0.26
Threonine, %	0.84	0.77	0.76	0.76	0.75	0.73	0.68	0.64	0.63	0.61	0.59	0.55
Tryptophan, %	0.29	0.26	0.24	0.27	0.23	0.24	0.24	0.22	0.22	0.23	0.19	0.21
Valine, %	1.07	0.94	0.87	0.98	0.90	0.84	0.90	0.79	0.72	0.82	0.62	0.61
Isoleucine, %	0.94	0.81	0.72	0.84	0.76	0.69	0.76	0.66	0.61	0.67	0.51	0.50
ME, mcal kg^{-1}	3.39	3.39	3.39	3.41	3.39	3.39	3.37	3.39	3.33	3.33	3.09	3.33
Sulfur, %	0.21	0.20	0.21	0.20	0.19	0.19	0.18	0.18	0.18	0.18	0.16	0.26

Grower phase 1: duration = 28 d, average initial bodyweight = 24.5 kg;
Grower phase 2: duration = 28 d, average initial bodyweight = 55.3 kg;
Finisher phase 1: duration = 21 d, average initial bodyweight = 87.2 kg;
Finisher phase 2: duration = 7 d, average initial bodyweight = 111.4 kg

Materials and Methods

- Feed offered daily
  - 10% above expected intake
- Refusals weighed each phase
- Feed sampled weekly

Materials and Methods

- Pigs weighed weekly
- Pen stocking rate reduced to 5 pigs per pen for F1 and F2
- Manure pans partially cleaned twice weekly
  - Volume removed was weighed and sub-sampled

Emissions Measurements

- Exhaust air sampled continuously from each room
  - 15 min per room plus 20 min for background
  - Concentration of $\mathbf{NH_3}$, NO, NO_x, $\mathbf{H_2S}$, CO_2, CH_4
- Airflow measured and recorded every 30 sec
- Concentration × flow = emission

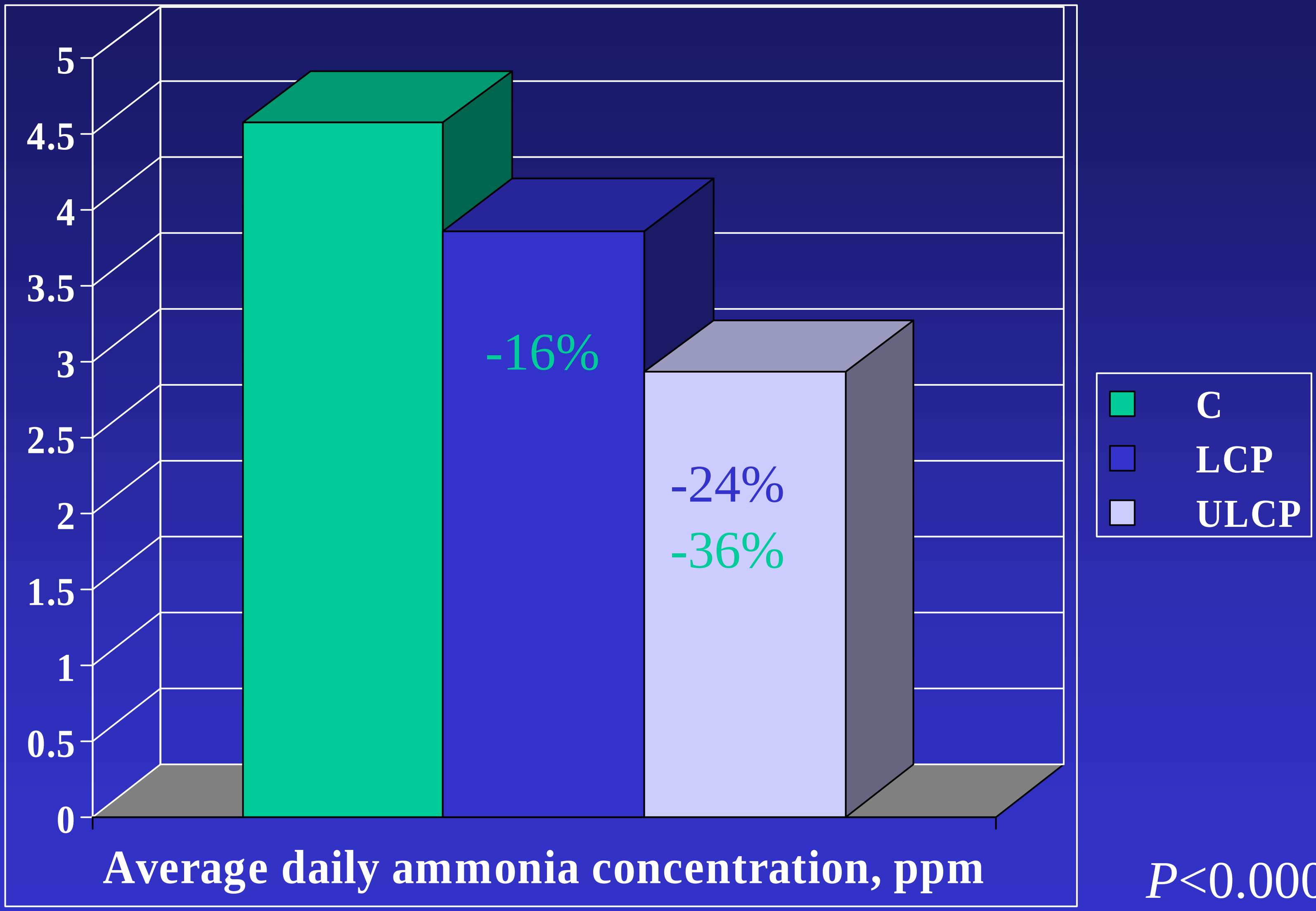
Results

Animal performance

Diet	*ADG, kg*	*ADFI, kg*	*F:G*
C	1.06	2.73	2.98
LCP	1.08	2.78	2.67
ULCP	1.07	2.95	3.05
P-value	0.9793	0.0954	0.4113

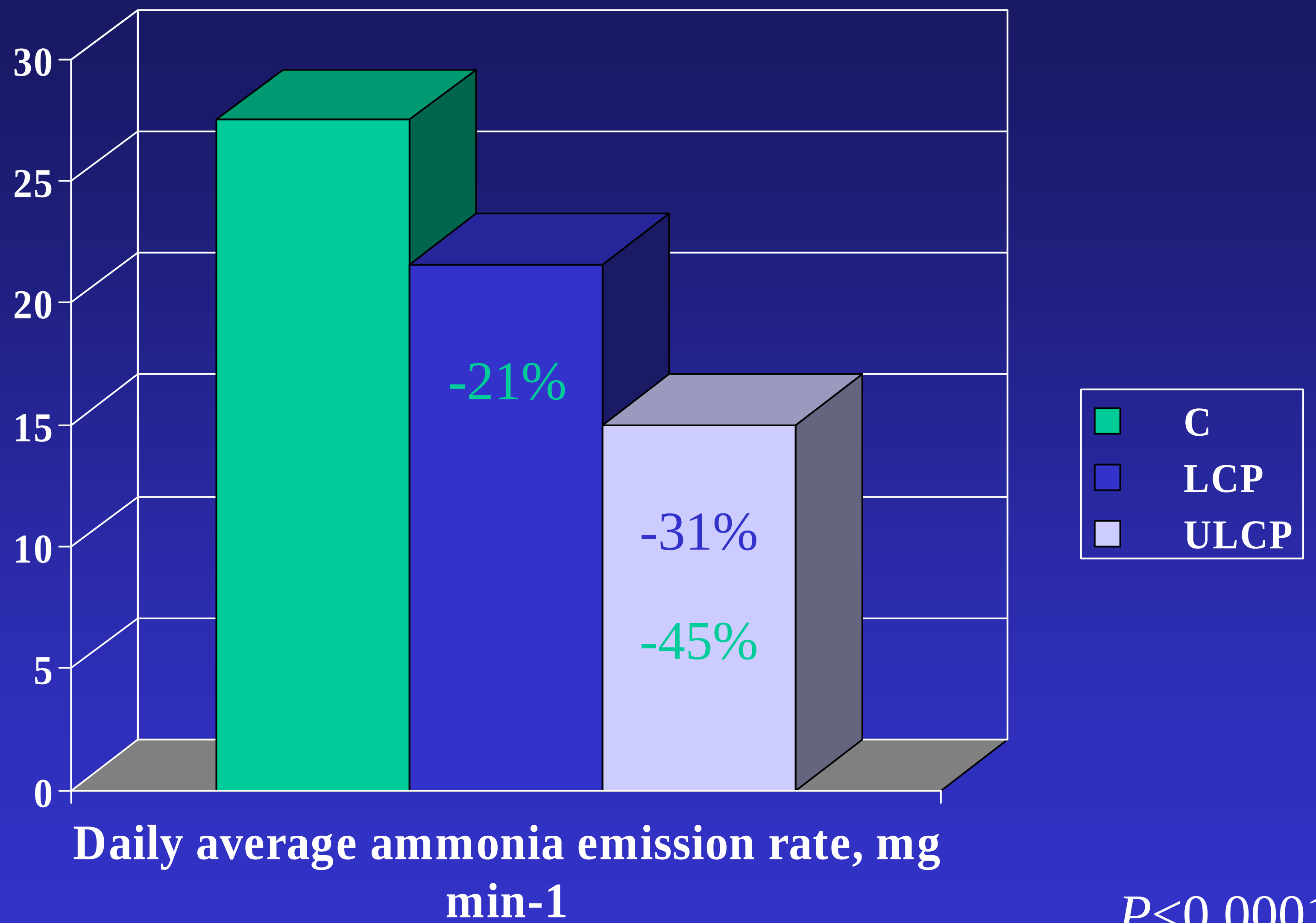
Manure volume produced

Diet	*Daily manure and waste, kg*	*Daily waste produced per kg liveweight, kg*
C	51.7	0.13
LCP	51.9	0.14
ULCP	48.1	0.12
P-value	0.4388	0.1335



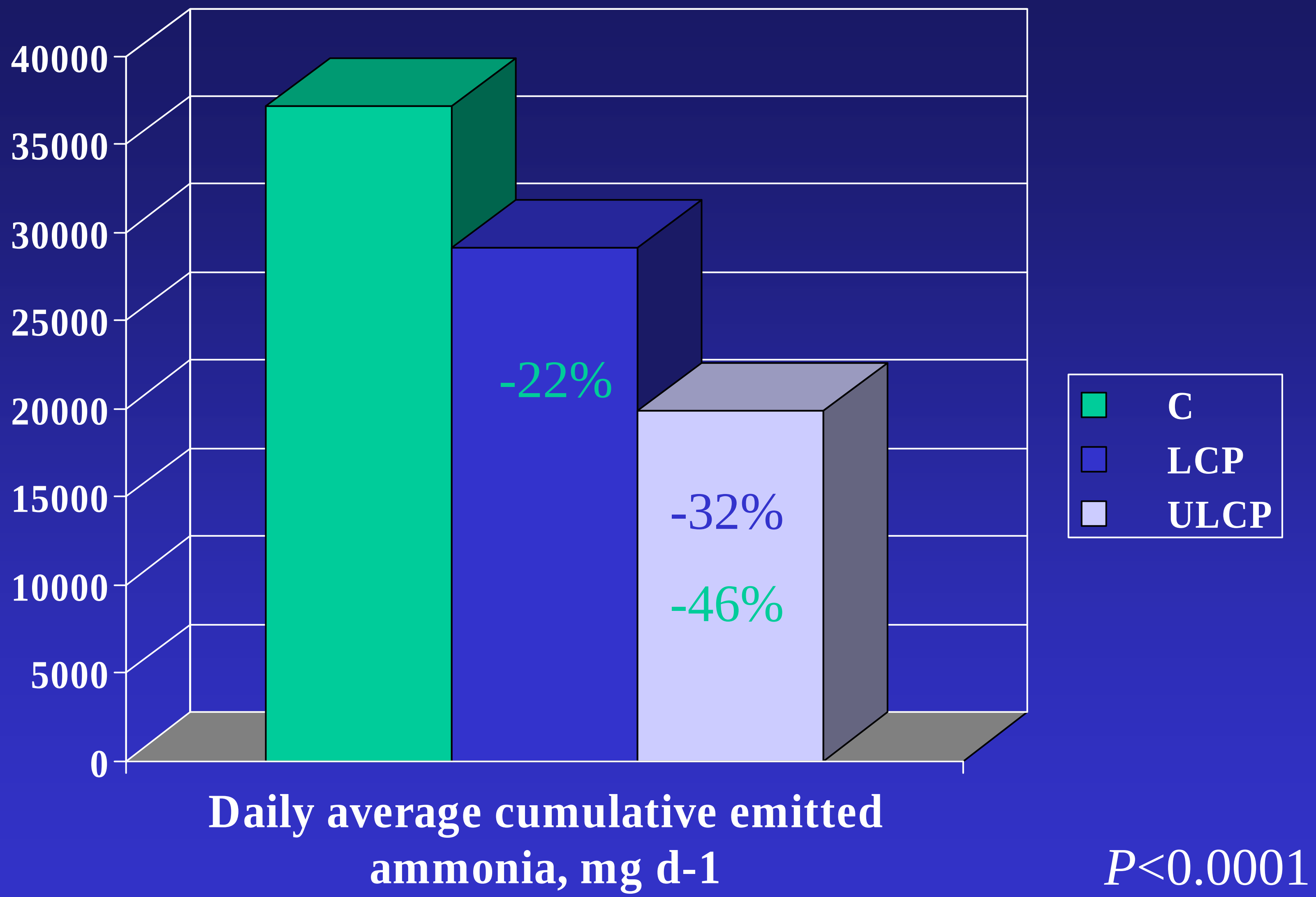
P<0.0001

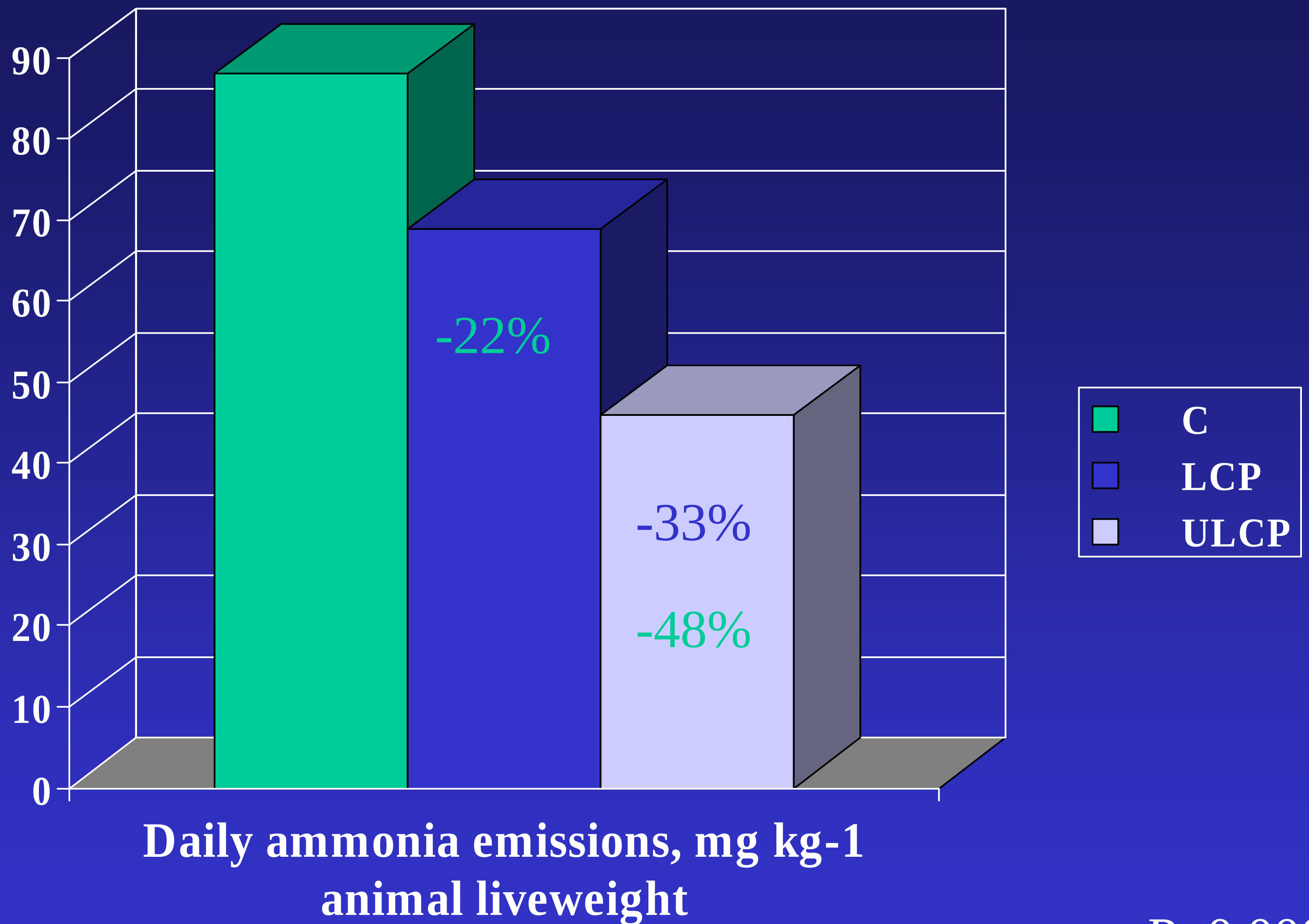
Std err = 0.2 ppm



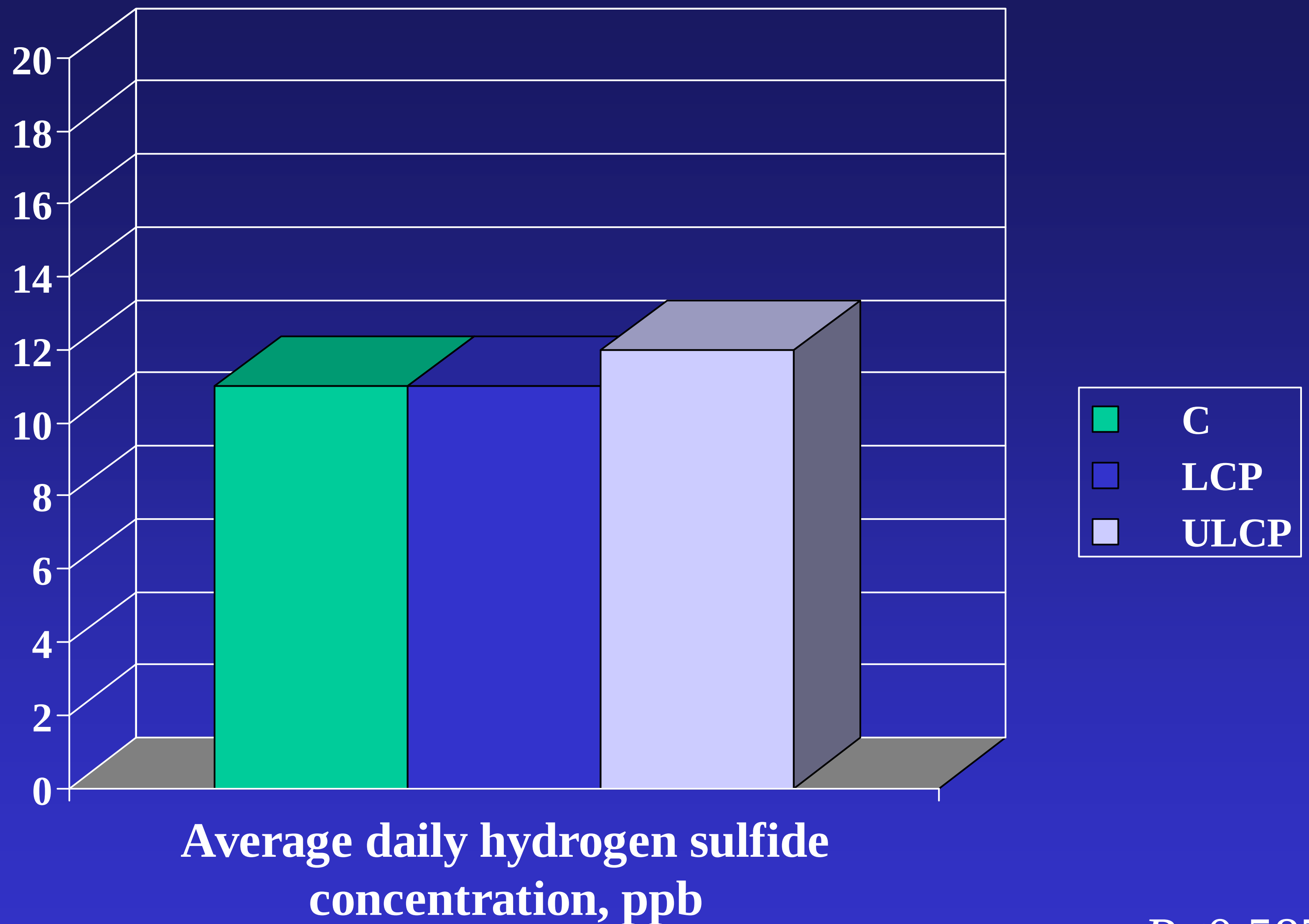
P<0.0001

Std err = 0.9 mg/min


40000
35000
30000
25000
20000
15000
10000
5000
0
-22%
-32%
-46%
C
LCP
ULCP
Daily average cumulative emitted ammonia, mg d-1
P<0.0001


90
80
70
60
50
40
30
20
10
0
-22%
-33%
-48%
C
LCP
ULCP
Daily ammonia emissions, mg kg-1 animal liveweight

P<0.0001



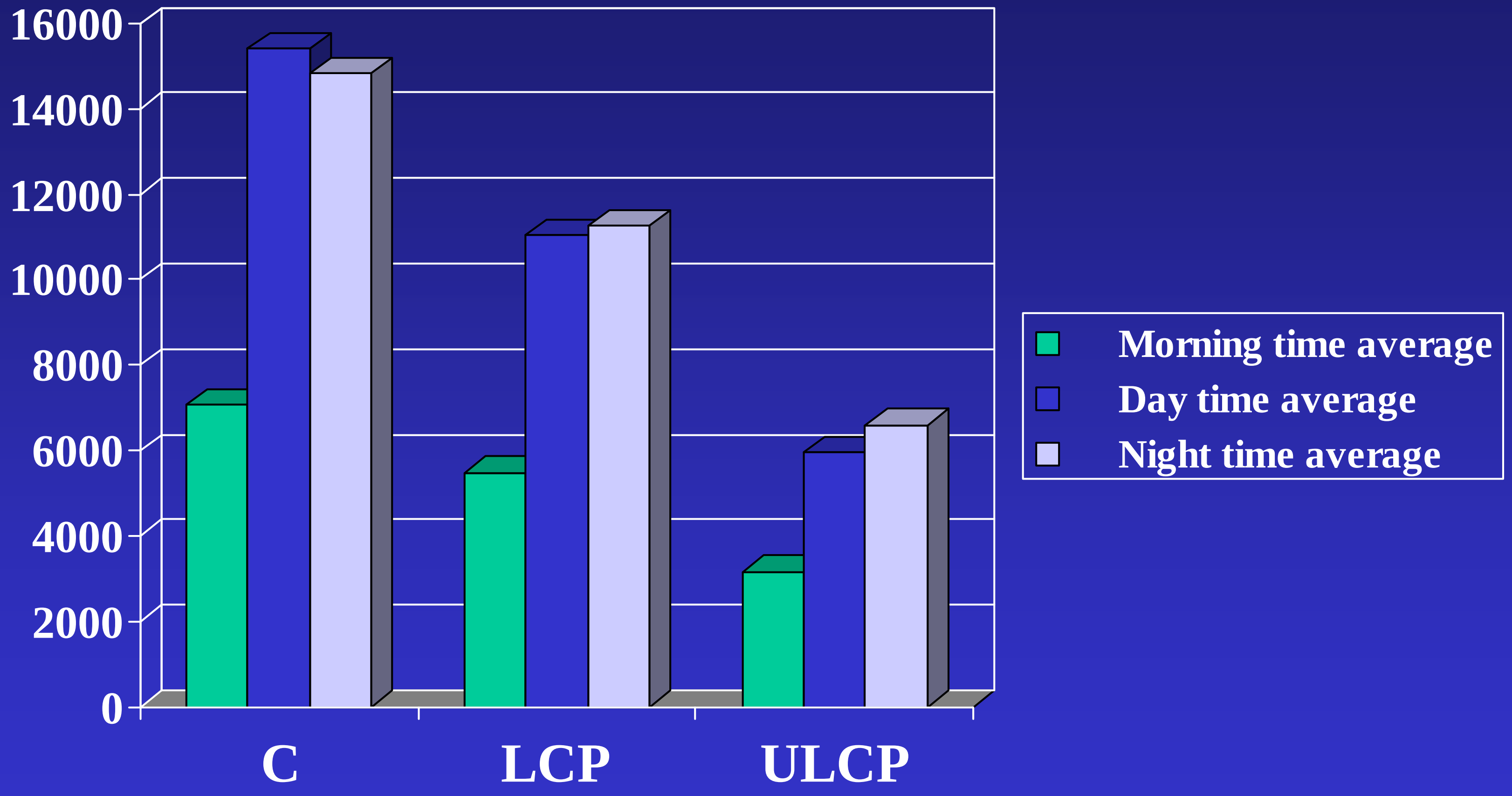
P<0.5877

Std err = 1 ppb

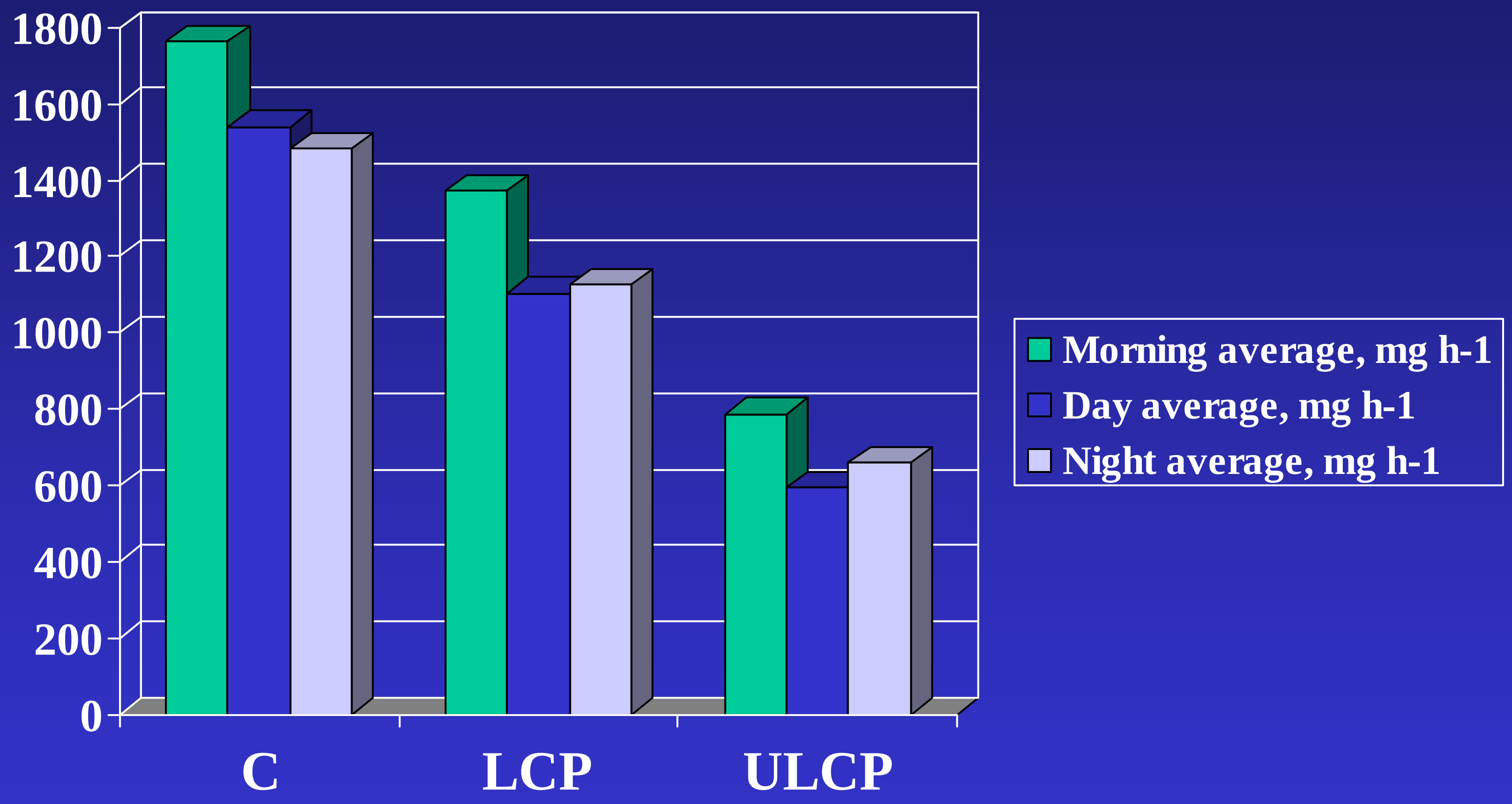
Hydrogen sulfide emissions

Diet	*Daily average emission rate, mg min^{-1}*	*Average cumulative mass, mg d^{-1}*	*Emissions, mg kg^{-1} animal liveweight*
C	0.109	134.7	0.35
LCP	0.124	138.6	0.35
ULCP	0.146	184.6	0.47
P-value	0.3166	0.296	0.3255

Cumulative ammonia emission mass, mg d-1



Cumulative ammonia emission mass, mg h-1



Conclusions

- Inclusion of five synthetic amino acids did not reduce animal performance
- The ammonia emission factor was reduced by 22% when three amino acids were supplemented and 48% when five amino acids were supplemented, compared to just Lys
- No impact on hydrogen sulfide emissions

Data Modeling

- Underway with UMD partner (Kohn)
- Performance, diet and emissions data from swine study considered

Facility timeline

- Swine: Sept 2004 – Mar 2005
- Laying hens: April – July 2005
- Broiler chickens: September – April 2006
- Turkeys: June – October 2006
- Dairy: October 2006?
- Growing cattle: 2007